

THE EFFECTS OF 21 DAYS HYPOXIA ON ELECTROMYOGRAPHIC ACTIVITY VARIATION IN ROWERS PRE AND POST-ALTITUDE

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The purpose of this study was to determine and to compare EMG characteristics of the vastus medial quadriceps in Chilean rowers in hypoxia. The sample was 11 Chilean elite rowers. The evaluation procedure consisted of every subject performing a maximal test of incremental ergospirometry intensity until fatigue. The EMG analysis was implemented when the sportsmen reached the VO₂max intensity with wireless EMG. In the analysis, RMS EMG signals were utilized. The results showed a significant difference between EMG activity in normoxia pre-altitude and normoxia post-altitude after 21 days in hypoxia.

KEY WORDS: rowing biomechanics, EMG, muscle activity.

INTRODUCTION: Sports competitions currently take place at a variety of geographical locations, each with its own suite of characteristics including wind, temperature, humidity and altitude. These variables can directly affect performance and results. Training at altitude can produce a range of changes in athletes, and disproportionately impacts resistance sports. The ergospirometry and physiological changes that hypoxia induces are relatively well documented; the effects of hypoxia at the neuromuscular level, however, are as yet not entirely clear, various hypothesis have tried to explain the electrophysiological and biochemical changes that occur as a consequence of the exposure to a high altitude environment and the changes that occur after a process of acclimatization, including adaptive changes that involve the muscle in conditions of hypobaric hypoxia (Kayser, Narici, Binzoni, Grassi, & Cerretelli, 1994; Narici & Kayser, 1995). In these situations they have reported a decrease in the total volume of muscle and subcutaneous fat after altitude training (MacDougall et al., 1991), but also in previous works they have shown a decrease in the transverse section area, specifically in fast fibers I (MacDougall et al., 1991). Also, in environments where there is a decrease in oxygen levels, there is a reduction in performance as a result of an increase in general fatigue or fatigue localized in a joint (Amann et al., 2013).

In the study of sports biomechanics, it is very useful to evaluate the moment when a contraction cannot be maintained, identified as failure or fatigue point, usually the moment when the muscle is said to have gone into fatigue. Muscle fatigue is characterized by central and peripheral adaptations that collectively impair performance (Enoka & Duchateau, 2016). Surface electromyography may be useful to investigate the adjustments associated with fatigue in muscle activity during sustained and repetitive contractions. A positive linear association between the increase in strength and amplitude in the EMG, in conjunction with the changes in frequency spectra at high frequencies, has been related to an increase in the recruitment of the motor units (Merletti & Parker, 2004). On the other hand, a negative linear association, with the decrease in force and changes in the frequency spectrum at low frequencies, has been associated with a decrease in the recruitment of motor units and the presence of peripheral fatigue (Merletti & Parker, 2004; Solomonow et al., 1990; Merletti, Knaflitz, & DeLuca, 1992). Previous work showed the sensitivity of the EMG during a fatigue test in a continuous and intermittent task. These works showed that the use of RMS during

dynamic contractions is a sensitive way of testing for muscle fatigue. The purpose of this study is was to determine and to compare EMG variation in vastus medial quadriceps in Chilean rowers, after of 21 days in hypoxia.

METHODS: The sample was composed of 11 elite rowers (5 male - 6 female) who have been members of Chilean teams for over 8 years. Throughout the study, he subjects continued with their normal daily trainings, following the regime determined by their trainer.

Table 1: General sample information (Mean±SD)

N	Age (years)	Body mass normoxia pre (Kg)	Body mass acute hypoxia (Kg)	Body mass chronic hypoxia (Kg)	Body mass normoxia post (Kg)
11	20.55±3.59	73.74±10.64	72.91±10.96	72.17±10.65	72.60±10.67

The subjects were evaluated in four test occasions: two tests in normoxia to 570 masl (pre-altitude normoxia and post-altitude normoxia) and two tests in hypoxia to 2880 masl (acute effect and chronic effect). Prior to testing, a short explanation was provided of the study, aims, procedures, and possibility of risk. This was accompanied immediately by a standardized protocol of warming up, which consisted of 10 minutes of rowing machine exercises, followed by 10 minutes of stretching exercises. After the warm up, the subjects were introduced to the ergospirometry protocol (VO₂max), with an incremental intensity of 20 watts power every one-minute until fatigue. The evaluation procedure consisted of every subject performing a maximal test of incremental ergospirometry intensity until fatigue. This was considered to be the visual execution analysis and the EMG parameters. The gathered information was: surface electromyography activity in the vastus medial quadriceps, at the moment when the sportsmen reach the intensity of VO₂max.

The position of the electrodes was marked on the skin according to the SENIAM® (surface electromyography for the non-invasive assessment of muscle). The electromiography signal was recorded with Delsys® Trigno, using silver surface bipolar electrodes (99%, 1 mm width and 10 mm length), with an inter-electrode distance of 10 mm. (Delsys Model Inc. Boston. M. USA). The signals registered were pre-amplific, with a common mode rejection ratio of 92dB and a gain of 1 kHz (Delsys Inc. Boston. USA). The electromyography signs were processed in a macrocomputer, with IGOR PRO Wavemetrics 5.01, and were rectified completely and passed through a 6Hz low-pass digital filter. The onset muscle activation was defined as basal level, which corresponded to the average amplitude recorded in a window before activation, with a threshold corresponding to the baseline value plus 10 standard deviations from that window. When the onset of the muscular electrical activity was determined, the magnitude of the response was calculated through RMS (root mean square).

To establish the EMG variation, it was not possible to do a Voluntary Maximum Contraction (CVM) test because the ergospirometry test was maximal and a CVM could alter effort intensity. For comparison between the four tests of electromyography activity in normoxia and the electromyography activity in hypoxia, the Friedman test was used for statistics and Post-hoc the Dunn's tests both with a significance level $p < 0,05$.

RESULTS: Table 2 shows the EMG activity and its contribution to the vastus medial in normoxia pre (570 masl), hypoxia acute (2880 masl), hypoxia chronic (2880 masl) and normoxia post (570 masl) during maximum level in the ergospirometry test. The electromyography activity of the vastus medial, during the maximal intensity in ergospirometry test, is higher in normoxia pre-altitude, with a standard deviation of 107.29 μ V. The average values of minor neuromuscle activity were demonstrated in normoxia post altitude with 119.89 μ V in muscle activity in the muscle vastus medial. In general terms, and considering the altitude in hipoxia (2880 masl) for both the acute effect of 48 hours and the chronic effect of two weeks, the electromyographic activity decreased even in post normoxia.

Table 2: Muscular activity RMS Vastus Medial during maximal level in ergospirometry test

	EMG normoxia pre (RMS μ V)	EMG acute hypoxia (RMS μ V)	EMG chronic hypoxia (RMS μ V)	EMG normoxia post (RMS μ V)
Media - Sd	193.64 \pm 107.29	145.85 \pm 112.10	128.70 \pm 57.43	119.89 \pm 59.64
EMG normoxia pre (RMS μ V)		0.285	0.191	0.03*
EMG acute hypoxia (RMS μ V)			0.959	0.994
EMG chronic hypoxia (RMS μ V)				0.995

EMG: Electromyography; RMS: Root Mean Square; Sd: standard deviation

* Statistically significantly differences

DISCUSSION: Significant differences were observed in the compared muscular contribution between pre-altitude normoxia with pos-altitude normoxia, where the muscle activity is smaller in pos-altitude normoxia ($p < 0.05$) for the same intensity of the ergospirometry test. A similar study of six male rowers from Peltonen shows that iEMG tends to be lower in hypoxia than in normoxia (Peltonen et al., 1997). Some previous studies suggest little effect of hypoxia on motor nerve conduction and muscle fiber excitability (Amann & Kayser, 2009) or on changes in the supraspinal control of the excitability of the stretch reflex (Delliaux & Jammes, 2006). Other authors demonstrated that exposure to chronic hypoxia might impair GABAergic cortical circuits, resulting in decreased inhibition of the motor cortex (Miyamoto & Auer, 2000; Di Lazzaro et al., 2000).

In support of our results, Taylor and Bronks (1996) observed similar iEMG responses in vastus medial at the same absolute intensities in normoxia and moderate hypoxia ($p = 0.135$) but during cycling (Taylor & Bronks, 1996).

CONCLUSIONS: The training in hypoxia (2880 masl) with duration 21 days in team Chilean rowing, decreased significantly the muscle activity in the vastus medial quadriceps between EMG pre-altitude normoxia and EMG post-altitude normoxia.

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